Parametric Study on Hub Vortex Reducing Effects of Propeller Boss Cap Fin by Force and Wake Field Measurements

Bumwoo Han, Hyundai Heavy Industries Co., Ltd., Seoul, Korea
Jeonghwa Seo, Dept. of Naval Architecture and Ocean Eng., Seoul National Univ., Seoul, Korea
Seung-Jae Lee, Research Institute of Marine Systems Eng., Seoul National Univ., Seoul, Korea
Shin Hyung Rhee, Dept. of Naval Architecture and Ocean Eng., Research Institute of Marine Systems Eng., Seoul National Univ., Seoul, Korea

Long Abstract

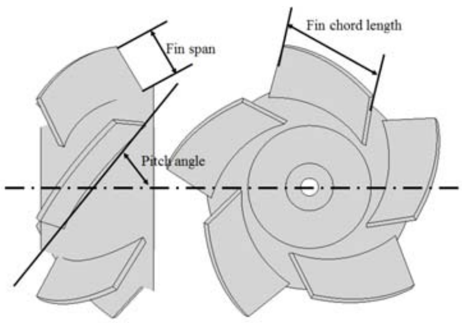
Introduction

Recently, high fuel efficiency is enforced for vessels in the maritime industries, due to the new regulation on energy efficiency design index (EEDI). Propeller boss cap fins (PBCF) is one of the most popular energy saving devices in the industry, to satisfy the EEDI requirements. Attaching fins with negative angle of attack, which generates negative torque and thrust, diminishes the hub vortex, which increase propulsive efficiency by approximately 5%, according to reports of sea trials [1] and full scale numerical simulation [2].

The present study aims to identify the correlation between propulsive efficiency and wake field of the propeller with various PBCF designs, with a focus on the hub vortex dynamics. The effects of PBCF on the wake field and propulsive efficiency were identified by tests in open water condition, and then investigation on hub vortex dynamics with various design parameters of PBCF followed.

1. Methods

A scaled model of KP505 propeller was used for this study. Design parameters of PBCF, which are the fin surface area and the angle of attack onto the fins, were varied to control fin loading. The fin surface area was varied by chaging the fin aspect ratio and fin chord length. The selected design parameters of PBCF and test conditions are presented in Figure 1.



	Pitch angle	Fin chord length	Fin aspect ratio
Standard boss cap	Without fins		
Baseline PBCF	46°	27.6 *mm*	0.35
Pitch angle variation	34, 40° (light loading) 52, 58° (heavy loading)	27.6 *mm*	0.35
Fin chord length variation	46°	17.3, 20.7, 24.2 *mm* (light loading) 31.1 *mm* (heavy loading)	0.35
Fin aspect ratio variation	46°	27.6 *mm*	0.15, 0.25 (light loading) 0.45, 0.55, 0.65 (heavy loading)

Figure 1. Design Parameters of PBCF and test conditions

2. Results and Discussion

Figure 2 shows the force and wake field measurement results of standard boss cap and baseline PBCF. In the wake field, root vortices generated from the propeller blades were separated by PBCF and did not form a strong hub vortex. As the pressue drop in the hub vortex induced drag on the boss cap, the hub vortex reduction practically increased total thrust, as evidenced in the force measurement results.

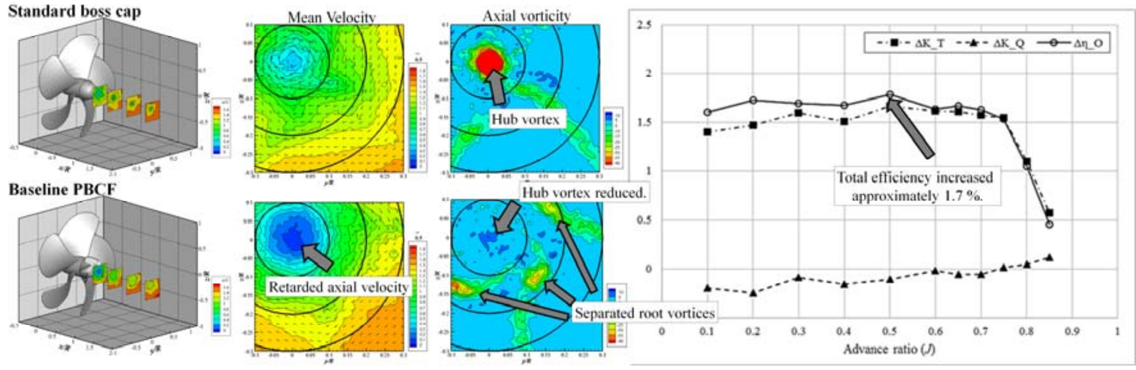


Figure 2. Wake Field and Global Force Measurement Results

Figure 3 shows the force measurement results with PBCF for various design parameters. Total efficiency increased linearly as the fin loading decreased with the pitch angle and fin chord length. In the case of fin aspect ratio, however, there was no linear dependency between total efficiency and fin loading. Instead it decreased in both the light and heavy loading conditions, and the maximum efficiency was observed in the mid–range value of the aspect ratio.

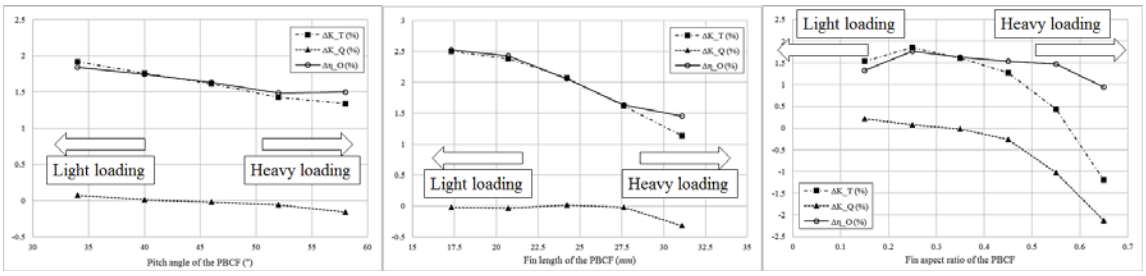


Figure 3. Changes of thrust and torque measurement results with various design parameters

References

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[2] T. Kawamura, K. Ouchi, and T. Nojiri. Model and full scale CFD analysis of propeller boss cap fins (PBCF). Journal of Marine Science and Technology, 17.4:469-480, 201